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Health and Environmental Effects Profile for 4-Bromophenyl Phenyl Ether

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HEALTH AND ENVIRONMENTAL EFFECTS PROFILE FOR 4-BROMOPHENYL PHENYL ETHER

ENVIRONMENTAL CRITERIA AND ASSESSMENT OFFICE
OFFICE OF HEALTH AND ENVIRONMENTAL ASSESSMENT
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OH 45268

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16. ABSTRACT

The Health and Environmental Effects Profile for 4-Bromophenyl Phenyl Ether was prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency Response to support listings of hazardous constituents of a wide range of waste streams under Section 3001 of the Resource Conservation and Recovery Act (RCRA) and to provide health-related limits for emergency actions under Section 101 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Both published literature and information obtained from Agency program office files were evaluated as they pertained to potential human health, aquatic life and environmental effects of hazardous waste constituents.

Quantitative estimates have been presented provided sufficient data are available. Existing data are insufficient to determine an Acceptable Daily Intake (ADI) or a carcinogenic potency factor for 4-bromophenyl phenyl ether.

The Reportable Quantity (RQ) value of 1, 10, 100, 1000 or 5000 pounds is used to determine the quantity of a hazardous substance for which notification is required in the event of a release as specified by CERCLA based on chronic toxicity. Existing data are insufficient to determine an RQ value.

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This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

Health and Environmental Effects Profiles (HEEPs) are prepared for the Office of Solid Waste by the Office of Health and Environmental Assessment. The HEEPs are intended to support listings of hazardous constituents of a wide range of waste streams under Section 3001 of the Resource Conservation and Recovery Act (RCRA). Both published literature and information obtained from Agency program office files are evaluated as they pertain to potential human health, aquatic life and environmental effects of hazardous waste constituents. The literature searched and the dates of the searches are included in the section titled "Appendix: Literature Searched."

Quantitative estimates are presented provided sufficient data are available. For systemic toxicants, these include, Acceptable Daily Intakes (ADIs) for chronic exposures. An ADI is defined as the amount of a chemical to which humans can be exposed on a daily basis over an extended period of time (usually a lifetime) without suffering a deleterious effect. In the case of suspected carcinogens, ADIs are not estimated in this document series. Instead, a carcinogenic potency factor or q_1^* is provided. These potency estimates are derived for both oral and inhalation exposures where possible. In addition, unit risk estimates for air and drinking water are presented based on inhalation and oral data, respectively.

The first draft of this document was prepared by Syracuse Research Corporation under EPA Contract No. 68-03-3228. The document was subsequently revised after reviews by staff within the Office of Health and Environmental Assessment: Carcinogen Assessment Group, Reproductive Effects Assessment Group, Exposure Assessment Group, and the Environmental Criteria and Assessment Office in Cincinnati.

The HEEPs will become part of the EPA RCRA docket.

ACKNOWLEDGEMENTS

The initial draft of this report was prepared by Syracuse Research Corporation under Contract No. 68-03-3228 for U.S. EPA's Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH. Dr. Christopher DeRosa was the Technical Project Monitor and Helen Ball was the Project Officer. The final documents in this series were prepared for the Office of Solid Waste, Washington, DC.

Scientists from the following U.S. EPA offices provided review comments for this document series:

Environmental Criteria and Assessment Office, Cincinnati, OH
Carcinogen Assessment Group
Exposure Assessment Group
Reproductive Effects Assessment Group

Editorial review for the document series was provided by:
Judith Olsen and Erma Durden
Environmental Criteria and Assessment Office, Cincinnati, OH

Technical support services for this document series were provided by:
Bette Zwayer, Pat Daunt, Karen Mann, and Jacky Bohanon
Environmental Criteria and Assessment Office, Cincinnati, OH.

EXECUTIVE SUMMARY

The U.S. EPA (Passow, 1982) identified 4-bromophenyl phenyl ether as an organic priority pollutant. Various physical and chemical properties are available for predicting its environmental fate and transport mechanisms. U.S. EPA (1977) reported that Velsicol Chemical Corp. and Columbia Organics Co. produce 4-bromophenyl phenyl ether, but SRI (1984) indicated Velsicol discontinued production of brominated flame retardants, possibly including 4-bromophenyl phenyl ether. No specific use data were located, but 4-bromophenyl phenyl ether could possibly be an impurity in flame retardant additives used in polymers.

Except for limited data on biodegradation, no pertinent experimental data regarding the environmental fate and transport of 4-bromophenyl phenyl ether were located. Based on its physical properties, however, prediction of some fate and transport mechanisms in air, water and soil was possible. In addition, some inferences can be drawn from experimental data for 4-chlorophenyl phenyl ether, a structural analog of 4-bromophenyl phenyl ether (Callahan et al., 1979).

Static-culture BOD assays of 4-bromophenyl phenyl ether resulted in no significant degradation (Tabak et al., 1981), while 95% of the pollutant was removed in an activated sludge system (Patterson and Kodukala, 1981). 4-Chlorophenyl phenyl ether has a reported half-life in activated sludge of ~4 hours, and varying biodegradation rates in river samples from different locations (Callahan et al., 1979).

Hydrolysis of 4-bromophenyl phenyl ether is not environmentally significant (Callahan et al., 1979; Mabey et al., 1981).

4-Bromophenyl phenyl ether absorbs UV wavelengths >290 nm (Sadtler, n.d.); therefore, direct photolysis may be possible in the environment. Irradiation of 4-chlorophenyl phenyl ether (wavelength >290 nm) resulted in phototransformation to diphenyl ether (Choudry et al., 1977).

Although not rapid, volatilization of 4-bromophenyl phenyl ether could be significant considering the Henry's Law constant of 1.02×10^{-4} atm·m³/mol (Lyman et al., 1982). The evaporation half-life of 4-chlorophenyl phenyl ether from a pond (1 m deep) was calculated to be ~7 hours (Callahan et al., 1979).

Using equations from Lyman et al. (1982) BCFs for 4-bromophenyl phenyl ether were calculated to be 3311 and 87,096, indicating that bioaccumulation is possible. The BCF for 4-chlorophenyl phenyl ether was experimentally determined to be 736±89 (Branson, 1977).

Calculated K_{oc} values for 4-bromophenyl phenyl ether indicate a potential for adsorption to suspended organic matter and sediments. 4-Chlorophenyl phenyl ether had a reported sediment to water ratio of 4:1 (Branson, 1977).

Estimated K_{oc} values for 4-bromophenyl phenyl ether indicate very low, slight or no mobility in soils (Swann et al., 1983). Considering the predicted tendency of 4-bromophenyl phenyl ether to adsorb to soils, evaporation from soil surfaces may be insignificant.

Isolated Alcaligenes BM-2 was incapable of degrading 4-bromophenyl phenyl ether (Yagi and Sudo, 1980), but because of insufficient data, no conclusions could be made regarding the significance of biodegradation in soil.

Data regarding food, inhalation and dermal exposure to 4-bromophenyl phenyl ether were not located in the available literature. The U.S. EPA STORET Data Base (U.S. EPA, 1986) provided quantitative data on the detection of 4-bromophenyl phenyl ether in water, sediments and fish tissue. 4-Bromophenyl phenyl ether has also been identified in drinking water, raw water and finished water, but quantitative data were unavailable (U.S. EPA, 1985). Lack of data precluded identification of emission sources, but it has been suggested that 4-bromophenyl phenyl ether forms during the chlorination of drinking water (U.S. EPA, 1983).

There is little information available concerning the toxicity of 4-bromophenyl phenyl ether to aquatic biota. Acute toxicity to three fish species was reported to occur at ~5 mg/ℓ (Applegate et al., 1957; EG&G Bionomics, 1978). In terms of acute toxicity, Daphnia magna was ~10 times more sensitive than the fish, having a 48-hour LC_{50} of 0.36 mg/ℓ (Leblanc, 1980). The only chronic toxicity data available were from secondary sources (U.S. EPA, 1980, 1985) which lacked detail and consisted of chronic values from fathead minnow embryo-larval tests. The geometric mean of the highest NOAEC and the LOAEC for adverse effects in growth and survival was 0.122 mg/ℓ (U.S. EPA, 1983).

Pertinent data regarding the absorption, distribution, metabolism and excretion of 4-bromophenyl phenyl ether could not be located in the available literature as cited in the Appendix.

4-Bromophenyl phenyl ether was negative in a pulmonary adenoma bioassay in strain A/ST mice (Ihiess et al., 1977) and for SCE in CD-1 mice (Borzelleca, 1983). Pertinent data regarding teratogenic or reproductive effects of 4-Bromophenyl phenyl ether were not located in the available

literature. Motor impairment developed in CD-1 mice treated by gavage with ≥58 mg/kg/day for 14 days (Borzelleca, 1983). Further data regarding the effects of repeated exposure to the chemical were not available.

Data were insufficient to derive an ADI or an RQ. 4-Bromophenyl phenyl ether is an IARC Group 3 chemical. Based on inadequate animal data and absence of human carcinogenesis data, 4-bromophenyl phenyl ether is classified as Group D (U.S. EPA, 1984), meaning this compound cannot be classified as a human carcinogen or ranked under CERCLA hazard ranking scheme.

TABLE OF CONTENTS

		Page
1.	INTRODUCTION	1
1.1.	STRUCTURE AND CAS NUMBER	1
1.2.	PHYSICAL AND CHEMICAL PROPERTIES	1
1.3.	PRODUCTION DATA	1
1.4.	USE DATA	2
1.5.	SUMMARY	2
2.	ENVIRONMENTAL FATE AND TRANSPORT PROCESSES	3
2.1.	WATER	3
2.1.1.	Hydrolysis	3
2.1.2.	Oxidation	3
2.1.3.	Photolysis	3
2.1.4.	Microbial Degradation	4
2.1.5.	Volatilization	5
2.1.6.	Adsorption	5
2.1.7.	Bioaccumulation	7
2.2.	AIR	7
2.3.	SOIL	8
2.3.1	Microbial Degradation	8
2.3.2	Chemical Degradation	8
2.3.3.	Leaching	8
2.3.4.	Volatilization	8
2.4.	SUMMARY	9
3.	EXPOSURE	11
3.1.	WATER	11
3.2.	SUMMARY	11
4.	PHARMACOKINETCS	13
5.	EFFECTS	14
5.1.	CARCINOGENICITY	14
5.2.	MUTAGENICITY	14
5.3.	TERATOGENICITY	14
5.4.	OTHER REPRODUCTIVE EFFECTS	14
5.5.	CHRONIC AND SUBCHRONIC TOXICITY	14
5.6.	OTHER RELEVANT INFORMATION	15
5.7.	SUMMARY	15

TABLE OF CONTENTS (cont.)

	Page
6. AQUATIC TOXICITY	16
6.1. ACUTE	16
6.2. CHRONIC	16
6.3. PLANTS	16
6.4. RESIDUES	16
6.5. SUMMARY	18
7. EXISTING GUIDELINES AND STANDARDS	19
7.1. HUMAN	19
7.2. AQUATIC	19
8. RISK ASSESSMENT	20
9. REPORTABLE QUANTITIES	21
9.1. REPORTABLE QUANTITY (RQ) RANKING BASED ON CHRONIC TOXICITY	21
9.2. WEIGHT OF EVIDENCE AND POTENCY FACTOR ($F=T/ED_{10}$) FOR CARCINOGENICITY	21
10. REFERENCES	23
APPENDIX: LITERATURE SEARCHED	27

LIST OF TABLES

No.	Title	Page
2-1	Calculated K_{OC} Values for 4-Bromophenyl Phenyl Ether. . . .	6
6-1	Toxicity of 4-Bromophenyl Phenyl Ether to Aquatic Organisms .	17
9-1	Minimum Effective Dose (MED) and Reportable Quantity (RQ) . .	22

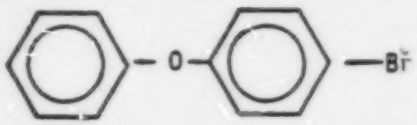
LIST OF ABBREVIATIONS

BCF	Bioconcentration factor
BOD	Biological oxygen demand
CAS	Chemical Abstracts Service
GC	Gas chromatography
K_{oc}	Soil sorption coefficient
K_{ow}	Octanol/water partition coefficient
LC_{50}	Concentration lethal to 50% of recipients (and all other subscripted dosage levels)
LOAEC	Lowest-observed-adverse-effect concentration
MATC	Maximum acceptable toxicant concentration
n.d.	No date
NOAEC	No-observed-adverse-effect concentration
PCB	Polychlorinated biphenyl
ppm	Parts per million
RQ	Reportable quantity
SCE	Sister chromatid exchange
UV	Ultraviolet

1. INTRODUCTION

1.1. STRUCTURE AND CAS NUMBER

4-Bromophenyl phenyl ether is also known as 1-bromo-4-phenoxy ether, p-bromophenyl phenyl ether, p-bromodiphenyl ether and p-bromophenoxybenzene. The structure, molecular weight, chemical formula and CAS Registry number are as follows:



Chemical formula: $C_{12}H_9BrO$

Molecular weight: 249.11

CAS Registry number: 101-55-3

1.2. PHYSICAL AND CHEMICAL PROPERTIES

The U.S. EPA (Passow, 1982) has identified 4-bromophenyl phenyl ether as an organic priority pollutant. Selected physical and chemical properties of this compound are listed below (Callahan et al., 1979; Mabey et al., 1981):

Melting point:	18.72°C
Boiling point:	310.14°C
Vapor pressure (at 20°C):	0.0015 mm Hg
Water solubility (at 25°C):	4.8 mg/ℓ (calculated)
Log K_{ow}:	4.94 (calculated)

1.3. PRODUCTION DATA

U.S. EPA (1977) listed the following companies as manufacturers of 4-bromophenyl phenyl ether: Velsicol Chemical Corporation, St. Louis, MO; Eastman-Kodak, Rochester, NY; and Columbia Organic Chemicals Company, Columbia, SC. Columbia produced <1000 pounds; Kodak no longer produces it;

and Velsicol production information was confidential. SRI (1984) indicated that Velsicol discontinued production of brominated flame retardants, which could possibly include 4-bromophenyl phenyl ether. Brominated diphenyl ethers are prepared by the bromination of diphenyl ether in the presence of a Friedel-Crafts catalyst (Larson, 1979). More specific details on this manufacturing process were not available.

1.4. USE DATA

In general, brominated diphenyl ethers are used as flame retardant additives in polymers (Larson, 1979). Therefore, 4-bromophenyl phenyl ether may be found as an impurity in commercially available brominated flame retardants.

1.5. SUMMARY

The U.S. EPA (Passow, 1982) has identified 4-bromophenyl phenyl ether as an organic priority pollutant. The U.S. EPA (1977) reported that Velsicol Chemical Corp. and Columbia Organic Co. produce this compound; but SRI (1984) indicated Velsicol discontinued production of brominated flame retardants, possibly including 4-bromophenyl phenyl ether. No specific use data were located, but 4-bromophenyl phenyl ether may be an impurity in flame retardant additives used in polymers.

2. ENVIRONMENTAL FATE AND TRANSPORT PROCESSES

2.1. WATER

2.1.1. Hydrolysis. The limited information available indicates that the hydrolysis of 4-bromophenyl phenyl ether is not expected to occur in ambient waters. Callahan et al. (1979) considered the hydrolysis of 4-bromophenyl phenyl ether to be unlikely, since the negative charge-density of the aromatic ring would be expected to impede the nucleophilic attack of water. Mabey et al. (1981) reported a hydrolysis rate constant of zero and stated that hydrolysis of 4-bromophenyl phenyl ether is not environmentally significant.

2.1.2. Oxidation. Pertinent data regarding the oxidation of 4-bromophenyl phenyl ether could not be located in the available literature as cited in the Appendix.

2.1.3. Photolysis. No experimental data regarding the photolysis of 4-bromophenyl phenyl ether were located in the available literature as cited in the Appendix. The UV absorption spectrum for 4-bromophenyl phenyl ether indicates absorption of wavelengths >290 nm (Sadtler, n.d.); therefore, direct photolysis may occur in the environment. No further information was available to estimate the rate of photolysis. When 4-chlorophenyl phenyl ether [a structural analog that behaves similarly to 4-bromophenyl phenyl ether (Callahan et al., 1979)] was irradiated (wavelength >290 nm) in a methanol solution, phototransformation occurred yielding diphenyl ether (Choudry et al., 1977). Apparently, diphenyl ether does not absorb electromagnetic radiation >300 nm; however, there is the possibility of a photochemically-induced rearrangement that yields ortho- and para-hydroxybiphenyl (Callahan et al., 1979). There has been speculation that 4-bromophenyl phenyl ether can undergo indirect photolysis in water by the interaction of

OH radicals with the aromatic ring (U.S. EPA, 1983), but Dorfmann and Adams (1973) reported that photohydroxylation of 4-bromophenyl phenyl ether is considered too slow to be environmentally significant.

2.1.4. **Microbial Degradation.** It is not possible to determine the significance of the microbial degradation of 4-bromophenyl phenyl ether in ambient waters since experimental data are limited. Static screening-flask assays were performed with 5 and 10 mg/ℓ concentrations of 4-bromophenyl phenyl ether using BOD dilution water enriched with 5 mg/ℓ yeast extract and a 7-day static incubation period in the dark at 25°C, followed by three weekly subculture redoses (totalling 28 days of incubation) (Tabak et al., 1981). Analysis by GC, dissolved organic carbon and total organic carbon revealed no significant biotransformation activity (Tabak et al., 1981). When the influent to a full-scale activated sludge treatment system was spiked with 360 µg/ℓ 4-bromophenyl phenyl ether, 95% of the pollutant was removed (Patterson and Kodukala, 1981). The latter study may not be indicative of biodegradation in the environment because the microbial population in activated sludge is much greater than the population in ambient water (Callahan et al., 1979).

4-Bromophenyl phenyl ether may exhibit properties similar to 4-chlorophenyl phenyl ether with respect to biodegradation (Callahan et al., 1979). The biodegrative half-life of 4-chlorophenyl phenyl ether in activated sludge is ~4 hours (Callahan et al., 1979). River die-away tests were performed using water samples taken from two different locations in the Tittabawasse River. At a concentration of 1 mg/ℓ of 4-chlorophenyl phenyl ether, one sample exhibited no detectable degradation before 120 hours; the other sample, no degradation before 312 hours. In the first and second samples, >90% degraded in 264 and 528 hours, respectively (Callahan et al.,

1979). Callahan et al. (1979) reported that in a nonstagnant body of surface water, a distinct microbial population would probably not be in contact with the pollutant long enough to become acclimated.

2.1.5. Volatilization. Pertinent experimental data regarding the volatilization of 4-bromophenyl phenyl ether could not be located in the available literature as cited in the Appendix. Henry's Law constant was calculated from the vapor pressure at 20°C (0.0015 mm Hg) and the water solubility at 25°C (4.8 mg/ℓ) using the following equation (Lyman et al., 1982):

$$H = P_{vp}/S$$

where P_{vp} is vapor pressure in atm and S is solubility in mol/m³. A Henry's Law constant of 1.02×10^{-4} atm·m³/mol indicates that volatilization may be significant but not rapid from water surfaces. The evaporation rate constant for 4-chlorophenyl phenyl ether was calculated by Branson (1977) to be 7.0 cm/hour using the method of Liss and Slater (1974). For a pond 1 m deep, the corresponding volatilization half-life is ~7 hours (Callahan et al., 1979). A similarly calculated rate constant can be expected for the structurally analogous 4-bromophenyl phenyl ether. Since it is highly probable that halogenated diphenyls will sorb to organic particulates and suspended clays, thus increasing the half-life, the calculated evaporation half-life should be considered a minimum value (Callahan et al., 1979).

2.1.6. Adsorption. No pertinent experimental data regarding the adsorption of 4-bromophenyl phenyl ether were available; however, K_{oc} values were calculated and are listed in Table 2-1. These relatively high K_{oc} values indicate potential for adsorption to suspended organic matter and sediments. In addition, the polar nature of the ether bond and the

TABLE 2-1

Calculated K_{OC} Values for 4-Bromophenyl Phenyl Ether

Equation	S	K_{OC}	Reference
$\log K_{OC} = -0.55 \log S + 3.64$	4.8 mg/ℓ	1,842	Lyman et al., 1982
$\log K_{OC} = -0.54 \log S + 0.44$	3.47×10^{-7}	8,477	Lyman et al., 1982
$\log K_{OC} = -0.557 \log S + 4.277$	19.3 µmol/ℓ	3,639	Lyman et al., 1982
Molecular topology and quantitative structure-activity analysis	NA	16,350	Sabljic, 1984

NA = Not applicable

miscibility of 4-bromophenyl phenyl ether with most lipophilic materials ensures adsorption to organic matter (Callahan et al., 1979). Sorption by clay particles is also considered to be highly probable, since the polarity and planar geometry of this molecule should facilitate interspersion within the layered clay structure (Callahan et al., 1979). A possible indication of sorption to sediments by 4-bromophenyl phenyl ether is given by a sediment to water ratio of 4:1 for the structural analog, 4-chlorophenyl phenyl ether (Branson, 1977).

2.1.7. Bioaccumulation. No experimental data for the bioaccumulation of 4-bromophenyl phenyl ether were located. The relatively high K_{ow} and low water solubility suggest a potential for bioaccumulation in aquatic organisms (Kenaga, 1980). The BCFs for 4-bromophenyl phenyl ether were calculated to be 3311 and 87,096 using log K_{ow} = 4.94 and the following equations, respectively (Lyman et al., 1982):

$$\log BCF = 0.76 \log K_{ow} - 0.23 \qquad (2\text{-}1)$$

$$\log BCF = 2.791 - 0.564 \log S \qquad (2\text{-}2)$$

Since the BCFs were >1000, bioaccumulation may be a significant removal process (Kenaga, 1980). The BCF for the structural analog, 4-chlorophenyl phenyl ether, was experimentally determined to be 736±89 in rainbow trout muscle (Branson, 1977).

2.2. AIR

Pertinent experimental data regarding the fate and transport of 4-bromophenyl phenyl ether could not be located in the available literature as cited in the Appendix. 4-Bromophenyl phenyl ether may undergo photolysis in the atmosphere, since UV wavelenghts >290 nm can be absorbed (Sadtler, n.d.); however no data are available to determine a rate constant.

2.3. SOIL

2.3.1. Microbial Degradation. In the only study of the microbial degradation of 4-bromophenyl phenyl ether available, Yagi and Sudo (1980) reported that isolated Alcaligenes BM-2, a strain of soil bacteria capable of using PCB (di-Cl) mixtures as their sole source of carbon, did not grow when 4-bromophenyl phenyl ether was the sole source of carbon.

2.3.2. Chemical Degradation. Hydrolysis is not expected to occur on wet soils based on information provided in Section 2.1.1. Based on the information provided in Section 2.2.1., photolysis on soil surfaces is a potential degradation mechanism.

2.3.3. Leaching. Experimental soil adsorption data could not be located in the available literature as cited in the Appendix; however, the relatively high K_{ow} and low water solubility of 4-bromophenyl phenyl ether suggest that adsorption to soil may be possible. To predict whether 4-bromophenyl phenyl ether will absorb to soil, K_{oc} values were calculated using the equations of Lyman et al. (1982) and the molecular topology and quantitative structure-activity relationship analysis method of Sabljic (1984) (see Table 2-1). The relatively high K_{oc} values indicate 4-bromophenyl phenyl ether should have very low, slight or no mobility in soils (Swann et al., 1983).

2.3.4. Volatilization. Pertinent data regarding the volatility of 4-bromophenyl phenyl ether could not be located in the available literature as cited in the Appendix. Considering the relatively high K_{oc} values (see Table 2-1), volatilization from soil surfaces may be insignificant. No further data were available to estimate the rate of volatilization from wet or dry soil surfaces.

2.4. SUMMARY

Except for limited data on biodegradation, no pertinent experimental data regarding the environmental fate and transport of 4-bromophenyl phenyl ether were located. Based on its physical properties, however, prediction of some fate and transport mechanisms in air, water and soil is possible. In addition, some inferences can be drawn from experimental data for 4-chlorophenyl phenyl ether, a structural analog of 4-bromophenyl phenyl ether (Callahan et al., 1979).

Static culture BOD assays of 4-bromophenyl phenyl ether resulted in no significant degradation (Tabak et al., 1981), while 95% of the pollutant was adsorbed or degraded in an activated sludge system (Patterson and Kodukala, 1981). 4-Chlorophenyl phenyl ether has a reported half-life in activated sludge of ~4 hours, and varying biodegradation rates in river samples from difficult locations (Callahan et al., 1979).

Hydrolysis of 4-bromophenyl phenyl ether is not environmentally significant (Callahan et al., 1979; Mabey et al., 1981).

4-Bromophenyl phenyl ether absorbs UV wavelengths >290 nm (Sadtler, n.d.); therefore, direct photolysis may be possible in the environment. Irradiation of 4-chlorophenyl phenyl ether (wavelength >290 nm) resulted in phototransformation to diphenyl ether (Choudry et al., 1977).

Although not rapid, volatilization of 4-bromophenyl phenyl ether could be significant considering the Henry's Law constant of 1.02×10^{-4} atm·m³/mol (Lyman et al., 1982). The evaporation half-life of 4-chlorophenyl phenyl ether from a 1 m deep pond was calculated to be ~7 hours (Callahan et al., 1979). Using equations from Lyman et al. (1982), BCFs for 4-bromophenyl phenyl ether were calculated to be 3311 and 87,096, indicating that bioaccumulation is possible (Kenaga, 1980). The BCF for 4-chlorophenyl phenyl ether was experimentally determined to be 736±39 (Branson, 1977).

Calculated K_{oc} values for 4-bromophenyl phenyl ether indicate a potential for adsorption to suspended organic matter and sediments. 4-Chlorophenyl phenyl ether phenyl ether had a reported sediment to water ratio of 4:1 (Branson, 1977).

Estimated K_{oc} values for 4-bromophenyl phenyl ether indicate very low, slight or no mobility in soils (Swann et al., 1983). Considering the predicted tendency of 4-bromophenyl phenyl ether to adsorb to soils, evaporation from soil surfaces may be insignificant.

Isolated Alcaligenes BM-2 was incapable of degrading 4-bromophenyl phenyl ether (Yagi and Sudo, 1980), but because of insufficient data, no conclusions could be made on the significance of biodegradation in soil.

3. EXPOSURE

3.1. WATER

Data were available regarding exposure to 4-bromophenyl phenyl ether in water, but not for food, inhalation and dermal exposure. Monitoring data from the U.S. EPA STORET Data Base (U.S. EPA, 1986) are as follows:

	Water	Sediment	Fish Tissue
Number of observations	5,979	892	626
Maximum concentration (µg/ℓ)	202,662	380,000	70.00
Minimum concentration (µg/ℓ)	0	0	0
Mean concentration (µg/ℓ)	113.226	2,791.90	1.835

4-Bromophenyl phenyl ether was included in a category with several other drinking water contaminants considered to be refractory to biodegradation; however, experimental data were not provided to support this inclusion (U.S. EPA, n.d.). 4-Bromophenyl phenyl ether was identified as a contaminant in finished drinking water three times, in raw water once and in river water once, but no quantitative data were provided (U.S. EPA, n.d.). Three tons of 4-bromophenyl phenyl ether are estimated to be discharged annually, but sources of discharge were not identified (U.S. EPA, n.d.). From the available manufacturing and use data, it is not possible to determine emission sources of 4-bromophenyl phenyl ether. It has been suggested that 4-bromophenyl phenyl ether is formed during chlorination of treated sewage and drinking water (U.S. EPA, n.d.).

3.2. SUMMARY

Data regarding food, inhalation and dermal exposure to 4-bromophenyl phenyl ether could not be located in the available literature as cited in the Appendix. The U.S. EPA STORET Data Base (U.S. EPA, 1986) provided quantitative data on the detection of 4-bromophenyl phenyl ether in water,

sediments and fish tissue. 4-Bromophenyl phenyl ether has also been identified in drinking water, raw water and finished water, but quantitative data were unavailable (U.S. EPA, n.d.). Lack of data precluded identification of emission sources, but it has been suggested that 4-bromophenyl phenyl ether forms during the chlorination of drinking water (U.S. EPA, n.d.).

4. PHARMACOKINETICS

Pertinent data regarding the absorption, distribution, metabolism and excretion of 4-bromophenyl phenyl ether could not be located in the available literature as cited in the Appendix.

5. EFFECTS

5.1. CARCINOGENICITY

Theiss et al. (1977) treated groups of 20 strain A/ST male mice with 23, 17 or 18 intraperitoneal injections of 4-bromophenyl phenyl ether in tricaprylin at dose levels of 40, 100 or 200 mg/kg/injection, respectively. The compound was given 3 times/week, and the mice were sacrificed 24 weeks after the first injection. No significant differences were found in the number of lung tumors/mouse or survival rates of treated mice compared with vehicle controls.

5.2. MUTAGENICITY

4-Bromophenyl phenyl ether was negative for SCE when tested in CD-1 mice treated by gavage with 58-579 mg/kg/day for 14 days (Borzelleca, 1983).

5.3. TERATOGENICITY

Pertinent data regarding the teratogenic effects of 4-bromophenyl phenyl ether could not be located in the available literature as cited in the Appendix.

5.4. OTHER REPRODUCTIVE EFFECTS

Pertinent data regarding the reproductive effects of 4-bromophenyl phenyl ether could not be located in the available literature as cited in the Appendix.

5.5. CHRONIC AND SUBCHRONIC TOXICITY

Pertinent data regarding the chronic and subchronic toxicity of 4-bromophenyl phenyl ether could not be located in the available literature as cited in the Appendix. The only available information regarding toxic effects of repeated exposure to 4-bromophenyl phenyl ether was reported by Borzelleca (1983). CD-1 mice treated by gavage with 4-bromophenyl phenyl

ether for 14 days developed motor impairment on the 14th day. The lowest dose producing the behavioral change was 58 mg/kg/day. Additional details were not provided.

5.6. OTHER RELEVANT INFORMATION

Other relevant information regarding 4-bromophenyl phenyl ether was not located in the available literature as cited in the Appendix.

5.7. SUMMARY

4-Bromophenyl phenyl ether was negative in a pulmonary adenoma bioassay in strain A/ST mice (Thiess et al., 1977) and for SCE in CD-1 mice (Borzelleca, 1983). Pertinent data regarding teratogenic or reproductive effects of 4-Bromophenyl phenyl ether could not be located in the available literature as cited in the Appendix. Motor impairment developed in CD-1 mice treated by gavage with $\geq$58 mg/kg/day for 14 days (Borzelleca, 1983). Additional data regarding the effects of repeated exposure to the chemical were not available.

6. AQUATIC TOXICITY

6.1. ACUTE

The limited information available concerning the toxicity of 4-bromophenyl phenyl ether to aquatic organisms is presented in Table 6-1. LC_{50} values for the fish species tested are $\geq$5 mg/ℓ. Adjusting the 96-hour LC_{50} of 4.9 mg/ℓ for the bluegill, Lepomis macrochirus, for test conditions and species sensitivity, U.S. EPA (n.d.) calculated a final acute value of 0.69 mg/ℓ for fish.

The only invertebrate species tested was Daphnia magna, which had LC_{50} values ~10 times smaller than fish (see Table 6-1). The 48-hour LC_{50} was 0.36 mg/ℓ (Leblanc, 1980), and from this LC_{50}, U.S. EPA (n.d.) calculated an acute value of 0.014 mg/ℓ for invertebrates.

6.2. CHRONIC

U.S. EPA (n.d.) reported that a chronic value of 0.061 mg/ℓ was determined in a fathead minnow, Pimephales promelas, embryo-larval test. This value was divided by a species sensitivity factor to obtain a final chronic value of 0.0091 mg/ℓ (U.S. EPA, n.d.). No other information was provided. Using a fathead minnow embryo-larval test, U.S. EPA (1980) calculated a chronic value of 0.122 mg/ℓ, but no details were provided.

6.3. PLANTS

Pertinent data regarding the effects of 4-bromophenyl phenyl ether on aquatic plants could not be located in the available literature as cited in the Appendix.

6.4. RESIDUES

Pertinent data regarding 4-bromophenyl phenyl ether residues in aquatic biota could not be located in the available literature as cited in the Appendix. U.S. EPA (1980) used K_{ow} values to calculate an estimated

TABLE 6-1

Toxicity of 4-Bromophenyl Phenyl Ether to Aquatic Organisms

Species	Concentration (mg/ℓ)	Effect	Reference
Bluegill *Lepomis macrochirus*	51	24-hour LC_{50}	Buccafusco et al., 1981
	50.9	24-hour LC_{50}	EG&G Bionomics, 1978
	9.6	48-hour LC_{50}	EG&G Bionomics, 1978
	4.9	72-hour LC_{50}	EG&G Bionomics, 1978
	4.9	96-hour LC_{50}	EG&G Bionomics, 1978
	5.9	96-hour LC_{50}	Buccafusco et al., 1981
	5.0	stress observed, 24 hours	Applegate et al., 1957
	0.69	acute value	U.S. EPA, n.d.
	<2.8	96-hour NOEC	EG&G Bionomics, 1978
Fathead minnow *Pimephales promelas*	>0.089, <0.167	MATC	EG&G Bionomics, 1978
	0.061	chronic value	U.S. EPA, n.d.
	0.0091	final chronic value	U.S. EPA, n.d.
	0.122	geometric mean, highest NOEC and LOAEC for adverse effects on growth and survival	U.S. EPA, 1983
Rainbow trout *Salmo gairdneri*	5.0	stress observed, 24 hours	Applegate et al., 1957
Sea lamprey *Petromyzon marinus*	5.0	stress observed, 24 hours	Applegate et al., 1957
Water flea *Daphnia magna*	0.46	24-hour LC_{50}	Leblanc, 1980
	0.36	48-hour LC_{50}	Leblanc, 1980
	<0.046	48-hour NOEC	Leblanc, 1980
	0.014	acute value	U.S. EPA, n.d.

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03/14/86

steady-state BCF of 4150 and a weighted average BCF for edible portions of fish and shellfish of 1640 for 4-bromophenyl phenyl ether.

6.5. SUMMARY

Little information is available concerning the toxicity of 4-bromophenyl phenyl ether to aquatic biota. Acute toxicity to three fish species was reported to occur at ~5 mg/ℓ (Applegate et al., 1957; EG&G Bionomics, 1978). In terms of acute toxicity, Japhnia magna was ~10 times more sensitive than the fish, having a 48-hour LC_{50} of 0.36 mg/ℓ (Leblanc, 1980). The only chronic toxicity data available were from secondary sources (U.S. EPA, n.d., 1980), which lacked detail and consisted of chronic values from fathead minnow embryo-larval tests. The geometric mean of the highest NOAEC and the LOAEC for adverse effects in growth and survival was 0.122 mg/ℓ (U.S. EPA, 1983).

7. EXISTING GUIDELINES AND STANDARDS

7.1. HUMAN

Pertinent guidelines and standards, including EPA ambient water and air quality criteria, drinking water standards, FAO/WHO ADIs, EPA or FDA tolerances for raw agricultural commodities or foods, and ACGIH, NIOSH or OSHA occupational exposure limits could not be located in the available literature as cited in the Appendix.

7.2. AQUATIC

U.S. EPA (n.d.) recommended a 24-hour average concentration of 0.0062 mg/ℓ as a criterion to protect freshwater aquatic life. U.S. EPA (n.d.) also stated that the maximum allowable concentration, which should not be exceeded at any time, was 0.014 mg/ℓ. Because of insufficient data, U.S. EPA (1980) did not derive an ambient water quality criterion for the protection of aquatic biota from 4-bromophenyl phenyl ether; however, U.S. EPA (1980) reported that the lowest concentrations that caused acute and chronic toxicity to freshwater aquatic life were 0.36 and 0.122 mg/ℓ, respectively.

8. RISK ASSESSMENT

In the only study available on the carcinogenicity of 4-bromophenyl phenyl ether (Theiss et al., 1977), no significant increased incidence of pulmonary tumor was observed in strain A/ST male mice injected intraperitoneally with doses $\leq$200 mg/kg/injection of 4-bromophenyl phenyl ether in corn oil, 3 times/week for 8 weeks. This short-term study should not, however, be regarded as an indication of the noncarcinogenicity of 4-bromophenyl phenyl ether (U.S. EPA, n.d.). Bromophenyl phenyl ether was negative for SCE when tested in CD-1 mice treated by gavage with 58-579 mg/kg/day for 14 days (Borzelleca, 1983). Teratogenicity and reproductive effect studies could not be located in the available literature as cited in the Appendix. Motor impairment developed in CD-1 mice treated by gavage with 4-bromophenyl phenyl ether at $\geq$58 mg/kg/day for 14 days (Borzelleca, 1983). Additional data regarding the effects of repeated exposure to the chemical were not available. No ADI is recommended at this time for bromophenyl phenyl ether.

9. REPORTABLE QUANTITIES

9.1. REPORTABLE QUANTITY (RQ) RANKING BASED ON CHRONIC TOXICITY

Pertinent data regarding the teratogenicity, other reproductive effects or chronic and subchronic toxicity of 4-bromophenyl phenyl ether could not be located in the available literature as cited in the Appendix. The only information located in the available literature regarding the toxic effects of repeated exposure to 4-bromophenyl phenyl was reported by Borzelleca (1983). CD-1 mice treated by gavage with the chemical at $\geq$58 mg/kg/day for 14 days developed motor impairment. The duration of this study is too short for these data to be used for RQ derivation. Thus, data are not sufficient for deriving an RQ (Table 9-1).

9.2. WEIGHT OF EVIDENCE AND POTENCY FACTOR ($F=1/ED_{10}$) FOR CARCINOGENICITY

Data regarding the carcinogenicity of 4-bromophenyl phenyl ether are limited. Negative results were obtained in a pulmonary adenoma assay in groups of 20 Strain A/ST male mice injected intraperitoneally with doses of 40, 100 or 200 mg/kg/injection 4-bromophenyl phenyl ether in tricaprylin, 3 days/week for up to 8 weeks (Thiess et al., 1977). Therefore, 4-bromophenyl phenyl ether is classified as an IARC Group 3 chemical. Based on inadequate animal data or absence of human carcinogenesis data, 4-bromophenyl phenyl ether is classified as Group D (U.S. EPA, 1984), meaning that the compound cannot be classified as a human carcinogen or ranked under CERCLA hazard ranking scheme.

TABLE 9-1

4-Bromophenyl Phenyl Ether

Minimum Effective Dose (MED) and Reportable Quantity (RQ)

Route:	
Dose:	
Effect:	
Reference:	
RV_d:	
RV_e:	
Composite Score:	
RQ:	Data are not sufficient for deriving an RQ.

10. REFERENCES

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APPENDIX

LITERATURE SEARCHED

This profile is based on data identified by computerized literature searches of the following:

CASR online (U.S. EPA Chemical Activities Status Report)
CAS onliine STN International
TOXLINE
TOXBACK 76
TOXBACK 65
RTECS
OHM TADS
STORET
SRC Environmental Fate Data Bases
SANSS
AQUIRE
TSCAPP
NTIS
Federal Register

These searches were conducted in September, 1985. In addition, hand searches were made of Chemical Abstracts (Collective Indices 6 and 7), and the following secondary sources were reviewed:

ACGIH (American Conference of Governmental Industrial Hygienists). 1980. Documentation of the Threshold Limit Values, 4th ed. (Includes Supplemental Documentation, 1981, 1982, 1983). Cincinnati, OH. 486 p.

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Verschueren, K. 1983. Handbook of Environmental Data on Organic Chemicals, 2nd ed. Van Nostrand Reinhold Co., NY.

Worthing, C.R. and S.B. Walker, Ed. 1983. The Pesticide Manual. British Crop Protection Council. 695 p.

Windholz, M., Ed. 1983. The Merck Index, 10th ed. Merck and Co., Inc., Rahway, NJ.

In addition, approximately 30 compendia of aquatic toxicity data were reviewed, including the following:

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